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Market Prepackaging Tests with Lemons

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MARKET PREPACKAGING TESTS WITH LEMONS

This report summarizes the results of five prepackaging tests with lemons conducted during 1947, 1948, and 1951 at the U. S. Market Pathology Laboratory at New York City. 1/

Results of tests 1 and 2

Test 1 was begun February 20, 1947, and test 2 on March 27, 1947. The two tests were alike in every respect so that they are discussed together. Ventura County, California. Lemons of 360 size were used. They were packaged in bags made of the following materials: (1) moisture-proof cellophane, 350 MSAT; (2) moisture-proof cellophane, 350 MSAT, with four 1/4 inch perforations per bag; (3) semi-moisture-proof cellophane, 300 LSAT; (4) cellulose acetate, CA 120; and (5) wet strength (50 pound) kraft paper with cellophane window. Unwrapped open chipboard trays were used as checks. Five lemons were placed in each package with the exception that in the CA lots four fruits in an open chipboard tray were enclosed within each bag. The MSAT and LSAT bags were closed by heat sealing, the CA bags were sealed with an adhesive and the kraft bags were stapled shut.

The packages were weighed, following which half were stored at 50° F. and half at 70°, with storage rooms having 65 and 50 percent relative humidity respectively. In each of the two tests four replicate packages of each film type were placed at each temperature. Observations were made at weekly intervals for four weeks to determine weight loss, color, external appearance and general salability or shelf life. Notes were also taken of the general appearance of the packages. At each of the first three inspections the packages were examined without being opened. At the fourth inspection, made at the end of the four-week storage period, all packages were opened and flavor tests made as the lemons were cut. The results of both tests are summarized together in table 1; each set of data is based on an average of eight packages.

1-week storage

At the 1-week inspection little difference was noted between the variously packaged fruit held at 50° F. with the exception that the lemons in the CA bags, kraft bags and check trays lost slightly more weight and in one test showed some loss of firmness. All packages held at this temperature were attractive in appearance. The fruit had bright color, good fresh appearance, and all packages were considered salable.

With the exception of one MSAT package that contained a decayed lemon, all packages stored for one week at 70° F. were considered salable. Weight loss was high in kraft bags and unwrapped checks, and fairly high in LSAT and CA bags. Loss in weight was accompanied by loss in firmness and plumpness of the lemons which were thus less attractive than comparable lots held at 50° F.

2-week storage

The fruit held at 50° F. continued to have excellent appearance. That in

1/ Part of project R-Sea-4 conducted under the Research and Marketing Act of 1946. Films supplied by Celanese Corp. of America, Sylvania Division of American Viscose Corp., E. I. duPont deNemours & Co., and Goodyear [illegible] Co. Kraft paper bags were furnished by Union Bag & Paper Company.

Table 1. Results of lemon prepackaging tests 1 and 2. Data based on averages from eight packages of each film for each temperature.

Film type	Stored at 50° F. Storage period (weeks)	Weight loss %	Freshness 1/	Salability	Stored at 70° F. Weight loss %	Freshness	Salability
MSAT	1	0.1	F.	Yes	0.8	F.	Yes 2/
MSAT-perf.	1	0.2	F.	"	1.3	"	"
LSAT	1	0.6	F.	"	6.8	"	"
CA	1	1.2	F.	"	8.4	"	"
Kraft	1	1.8	"	"	11.4	"	"
Naked-checks	1	1.6	"	"	11.8	"	"
MSAT	2	0.6	F.	Yes 2/	1.9	F.F.	Yes 2/
MSAT-perf.	2	0.6	"	" 2/	2.5	"	"
LSAT	2	1.6	"	"	9.0	"	"
CA	2	2.8	"	"	14.4	Dry	No
Kraft	2	3.6	"	"	19.0	"	"
Naked-checks	2	3.8	"	"	18.5	"	"
MSAT	3	1.6	F.	Yes 2/	5.2	F.F.	Yes 2/
MSAT-perf.	3	1.7	"	" 2/	6.7	"	"
LSAT	3	3.5	"	"	-	Shr.	No
CA	3	6.5	"	"	Discarded after second week.		
Kraft	3	8.0	"	"	"	"	" "
Naked-checks	3	8.9	"	"	"	"	" "
MSAT	4	2.7	F.	Yes	7.8	F.F.	Yes 2/
MSAT-perf.	4	2.8	"	Yes 2/	10.2	"	"
LSAT	4	5.4	"	"	Discarded after third week.		
CA	4	8.7	"	"	"	" second	"
Kraft	4	9.8	"	"	"	" "	"
Naked-checks	4	11.2	"	"	"	" "	"

1/ F. = Fresh; F.F. = Fairly Fresh; SHR. = Shriveled; Dry = Skin badly shrivelled, hard and dry.

2/ One of eight packages not salable because of presence of one lemon affected with Penicillium rot. The same package is represented in the 2, 3, and 4-week inspections.

the CA bags was somewhat more attractive than that in the other bags because of the excellent transparency of the film. The CA, kraft, and check packages continued to lose weight and showed a slight loss of turgidity. However, no visible wilting was noted.

After two weeks at 70° F. weight loss was very high in CA and kraft bags and in the check packages; consequently the lemons were dry and were considered unsalable. Those in LSAT bags lost considerable weight but were fairly fresh in appearance and, hence, were considered still salable. The fruit in MSAT bags was fairly fresh and still salable.

3-week storage

All fruit stored at 50° F. for three weeks had a good fresh appearance. Greatest weight loss along with a loss in firmness occurred in CA bags, kraft bags, and the checks. These packages were, however, still considered to be salable. Weight loss in LSAT bags was less than in the above packages but still was over twice as great as in either perforated or non-perforated MSAT bags.

All packages at 70° F. except LSAT and MSAT had been discarded after two weeks, after three weeks the LSAT bags were considered unsalable because of the poor appearance of the fruit. Lemons in perforated and non-perforated MSAT bags were still fairly fresh in appearance and were considered salable.

4-week storage

With the exception of one perforated MSAT package containing a decayed lemon, all packages stored four weeks at 50° F. were still salable and the fruit had a fresh appearance. However, considerable weight loss associated with loss of firmness occurred in the CA bags, kraft bags, and the unwrapped checks. The same was true, but to a lesser extent, in the LSAT bags. The fruit in perforated and non-perforated MSAT bags lost the least weight and remained fresh and fairly firm.

At 70° only the perforated and non-perforated MSAT packages remained at four weeks. Although the lemons were fairly fresh and were considered still salable, weight loss was quite high.

Results of test 3

The third test was begun January 13, 1948. California lemons of 360 size were packed four fruit per open chipboard tray overwrapped with the following films: (1) Pliofilm, 75NF; (2) Pliofilm, 75NF with four 1/4 inch perforations per package; (3) moisture-proof cellophane, 300 PMBS: (4) moisture-proof cellophane, 300 PMBS, with four 1/4 inch perforations per package; (5) semi-moisture-proof cellophane, 300 LSAT: (6) cellulose acetate, CA 100; and (7) unwrapped checks. There were 18 packages of each film type and six of each kind were placed at 40° F., 50° F., and 70° F. Relative humidities of 75, 65 and 60 percent respectively prevailed in the three rooms. Inspections were made at weekly intervals for four weeks in the manner described for tests 1 and 2. Two packages of each film type were sampled at each temperature at the one-week inspection, one package at the two-week, one at the three-week and two packages at the four-week inspection. At each inspection the packages

were opened and the lemons cut to determine their internal condition. Carbon dioxide and oxygen determinations of enclosed atmosphere were made of representative packages throughout the test.

The results of the test are summarized in table 2. The decay noted in footnote 4 of the table, representing a single lemon affected with Penicillium rot in each of two packages, constituted all that occurred during the test. Although the data are not shown in the table it may be stated that slight accumulation of carbon dioxide occurred in non-perforated Pliofilm packages (less than 1 percent) and in non-perforated CA packages (1.5 percent). An average carbon dioxide concentration of 4.0 percent was found in fourteen non-perforated PMBS packages and an average oxygen concentration of 15.5 percent in nine packages. The LSAT packages had an average concentration of 2.3 percent carbon dioxide; four other packages had an average concentration of 5.3 percent carbon dioxide and 15.5 percent oxygen. In no instance did abnormal odors or flavors develop.

1-week storage

At the 1-week inspection the lemons of all lots had a good fresh appearance with the exception that at 70° F. those in the LSAT and CA packages and the unwrapped checks were rated as only fairly fresh. This loss of freshness was associated with respective weight losses of 9.3, 11.7 and 15.8 percent, and the lemons were considered somewhat less desirable than the other lots. No physiological breakdown was observed. All packages were considered salable.

2-week storage

At the 2-week inspection LSAT, CA and check packages held at 70° F. showed 19.5, 23.8 and 27.8 percent weight loss respectively. The fruit was shriveled and was considered unsalable. These three lots were discontinued. All other lots were judged salable, with the notation that CA and check lots held at 42° F. and 50° F. were only fairly fresh.

3-week and 4-week storage

At the 3- and 4-week inspections the appearance of the 42° F. and 50° F. was much the same as at the 2-week inspection. Greatest weight loss occurred in the CA and check packages so that the lemons were rated as only fairly fresh, whereas those of the other lots had a fresh appearance. Some physiological breakdown was found at three weeks and even more at four weeks; its occurrence was not closely related either to film type or difference in storage temperature (42° F. vs. 50° F.). Approximately 30 percent of the packages stored at the lower two temperatures were considered unsalable at three weeks and 40 percent at four weeks.

Of the 70° F. lots only Pliofilm and PMBS packages were still available for 3- and 4-week inspections. Weight loss had increased since the 2-week inspection; in all instances the lemons were rated as only fairly fresh instead of fresh. No physiological breakdown occurred and all packages were considered to be salable.

Table 2. Results of lemon prepackaging test number 3.

Film type	Storage temperature °F.	Stored one week: Physiological breakdown 1/ %	Stored one week: Weight loss %	Stored one week: Freshness 2/	Stored one week: Salability	Stored two weeks: Physiological breakdown 1/ %	Stored two weeks: Weight loss %	Stored two weeks: Freshness 2/	Stored two weeks: Salability
Pliofilm	42°	0	0	F.	Yes	0	0.8	F.	Yes
Pliofilm-perf.	42°	0	0.5	"	"	0	0.7	"	"
PMBS	42°	0	0.3	"	"	0	0.5	"	"
PMBS-perf.	42°	0	0.4	"	"	0	0.8	"	"
LSAT	42°	0	1.1	"	"	0	2.5	"	"
CA	42°	0	1.8	"	"	0	3.8	F.F.	"
Check-naked	42°	0	2.2	"	"	0	4.4	"	"
Pliofilm	50°	0	0.4	F.	Yes	0	0.5	F.	Yes
Pliofilm-perf.	50°	0	0.2	"	"	0	0.5	"	"
PMBS	50°	0	0.6	"	"	0	0.5	"	"
PMBS-perf.	50°	0	0.2	"	"	0	0.7	"	"
LSAT	50°	0	0.7	"	"	0	1.8	"	"
CA	50°	0	1.1	"	"	0	2.0	F.F.	"
Check-naked	50°	0	1.3	"	"	0	4.4	"	"
Pliofilm	70°	0	2.0	F.	Yes	0	3.6	F.	Yes
Pliofilm-perf.	70°	0	2.3	"	"	0	4.0	"	"
PMBS	70°	0	1.7	"	"	0	4.4	"	"
PMBS-perf.	70°	0	2.4	"	"	0	5.2	"	"
LSAT	70°	0	9.3	F.F.	"	0	19.5	SHR.	No
CA	70°	0	11.7	"	"	0	23.8	"	"
Check-naked	70°	0	15.8	"	"	0	27.8	"	"

1/ Physiological breakdown includes membranous stain and a type of breakdown similar in appearance to internal decline. Slight stages that appeared to be of no commercial importance not included.

2/ F. = Fresh; F.F. = Fairly Fresh; SHR. = Shriveled.

(Table 2. - continued)

Film type	Storage temperature °F.	Stored three weeks: Physiological breakdown % [1]	Weight loss %	Freshness [2]	Salability	Stored four weeks: Physiological breakdown % [1]	Weight loss %	Freshness [2]	Salability
Pliofilm	42°	0	0.7	F.	Yes	13.0	1.0	F.	Half
Pliofilm-perf.	42°	0	1.5	"	"	0	1.3	"	Yes
PMBS	42°	25.0	1.0	"	No	0	1.2	"	"
PMBS-perf.	42°	0	1.0	"	Yes	50.0	1.6	"	No
LSAT	42°	0	0.7	"	"	50.0 [4]	4.0	"	No
CA	42°	0	4.9	F.F.	"	13.0	7.5	F.F.	Half
Check-naked	42°	0	7.1	"	"	13.0	8.9	"	"
Pliofilm	50°	0	0.5	F.	Yes	25.0	0.9	F.	Half
Pliofilm-perf.	50°	0	1.2	"	"	0	1.3	"	Yes
PMBS	50°	50.0	1.0	"	No.	13.0	0.8	"	Half
PMBS-perf.	50°	0	1.5	"	Yes	13.0	1.2	"	"
LSAT	50°	0	2.6	"	"	0	2.3	"	Yes
CA	50°	25.0	4.2	F.F.	No	13.0 [4]	3.5	F.F.	Half
Check-naked	50°	25.0	4.3	"	"	0	6.3	"	Yes
Pliofilm	70°	0	5.0	F.F.	Yes	0	7.2	F.F.	Yes
Pliofilm-perf.	70°	0	7.1	"	"	0	9.1	"	"
PMBS	70°	0	6.7	"	"	0	6.4	"	"
PMBS-perf.	70°	0	6.9	"	"	0	9.2	"	"
LSAT	70°	Discarded after second week.				Discarded after second week.			
CA	70°	"	"	"	"	"	"	"	"
Check-naked	70°	"	"	"	"	"	"	"	"

1/ Physiological breakdown includes membranous stain and a type of breakdown similar in appearance to internal decline. Slight stages that appeared to be of no commercial importance not included.

2/ F. = Fresh; F.F. = Fairly Fresh; SHR. = Shriveled.

3/ Half = One of two packages considered salable, the other unsalable.

4/ Including 13 percent Penicillium rot.

Results of test 4

Test 4 was conducted for the purpose of making a detailed comparison of lemons packaged in perforated moisture-proof cellophane with lemons packaged in non-perforated moisture-proof cellophane. Particular emphasis was placed on determining to what extent carbon dioxide was accumulated and oxygen depleted in non-perforated packages and on learning whether they were related to subsequent development of membranous stain or decay.

The test was begun July 18, 1951, with California lemons, size 300, purchased on the wholesale market. Two lots were used, each representing a different packing house (designated A and B). Thirty chipboard trays containing five lemons each were packed from each lot and overwrapped with moisture-proof cellophane, 350 MSAT. Half of the packages were then perforated with two one-quarter inch holes and half left with no perforations. Six trays of each lot (3 perforated and 3 non-perforated) were placed at 70° F. for inspection after one week. The remaining 24 were divided for storage as follows: 12 packages of each lot (6 perforated and 6 non-perforated) at 38° F. and 12 packages (6 perforated and 6 non-perforated) at 55° F. for four weeks. The relative humidity in both rooms was 85 percent. After four weeks' storage the packages were removed from storage and half of each group was inspected immediately while the remaining half of each group was placed at 70° F. for an additional week and then examined.

At each inspection determinations of carbon dioxide and oxygen were made within the packages and the lemons were examined externally and internally.

When the test was started five percent membranous stain was found in lot B lemons (20-fruit sample) and none in those of lot A. In the packages held at the start of the test for one week at 70° F. no increase in membranous stain was noted. At the end of this one-week holding period the carbon dioxide content of the atmosphere within the non-perforated packages ranged from 5.2 to 7.0 percent and the oxygen content from 14 to 16 percent.

The results from the storage test with the other 48 packages are summarized in table 3. Carbon dioxide accumulation and oxygen depletion were significant only in the non-perforated packages. About half of these showed a carbon dioxide content of five percent or greater (up to 18 percent); somewhat less than half showed the oxygen content of the enclosed atmosphere depleted to 15 percent or less (the minimum concentration reaching 5.5 percent). The large variation in gas concentration in the packages was possibly due to difference in gas-tightness of the seals. All membranous stain noted was scored as either trace or slight and none was considered commercially important. The data in table 3 clearly show that no relationship existed between prevalence of membranous stain and carbon dioxide or oxygen content of the package atmosphere. No abnormal odors or flavors were noted throughout the test. Taking into consideration all packages of the test, approximately 12 percent of the lemons from each of the two packing houses became affected with Penicillium rot.

Table 3. Results of lemon prepackaging test number 4. Data are given for each package examined.

Film type	Storage temperature ° F.	Packing house	Stored four weeks at indicated temperature: Carbon dioxide %	Oxygen %	Decay 1/ %	Membranous stain 2/ %	Stored four weeks at indicated temperature plus 1 addl. wk. at 70° F.: Carbon dioxide %	Oxygen %	Decay 1/ %	Membranous stain 2/ %
MSAT	38°	A	1.7	18.5	0	20.	2.0	19.5	0	20.
MSAT	38°	A	1.2	19.0	0	20.	9.4	11.0	40.	0
MSAT	38°	A	2.0	19.0	0	0	5.8	15.5	0	20.
MSAT-perf.	38°	A	0	20.0	0	0	0	20.0	0	0
" "	38°	A	-	-	0	20.	-	-	20.	20.
" "	38°	A	-	-	0	40.	-	-	0	40.
MSAT	38°	B	1.4	18.0	20.	0	14.4	10.5	0	0
"	38°	B	3.0	17.5	0	0	3.2	17.5	0	0
"	38°	B	2.0	17.0	0	0	8.6	16.5	60.	0
MSAT-perf.	38°	B	0	20.0	0	0	1.4	19.0	60.	0
" "	38°	B	-	-	0	0	0	20.0	0	0
" "	38°	B	-	-	0	0	-	-	0	0
MSAT	55°	A	18.0	10.0	40.	0	5.0	16.5	20.	20.
"	55°	A	4.6	16.5	0	20.	2.2	17.5	0	0
"	55°	A	6.0	15.0	20.	40.	13.0	9.5	60.	0
MSAT-perf.	55°	A	0	20.0	20.	0	0	20.0	0	20.
" "	55°	A	-	-	40.	40.	-	-	0	20.
" "	55°	A	-	-	60.	40.	-	-	0	20.
MSAT	55°	B	5.8	13.5	0	40.	15.4	5.5	20.	0
"	55°	B	9.6	9.0	0	0	3.8	17.2	0	20.
"	55°	B	5.8	14.0	0	0	11.8	8.0	100.	0
MSAT-perf.	55°	B	0	20.0	0	0	0	20.5	0	40.
" "	55°	B	-	-	0	20.	-	-	0	20.
" "	55°	B	-	-	0	20.	-	-	0	0

1/ All decay was Penicillium rot.
2/ All membranous stain was scored as a trace or slight and was not considered to be commercially important.

Results of test 5

A test similar to the preceding one, but on a more comprehensive scale, was conducted during July and August, 1951, with California lemons, 300 size, from a storage experiment in which four picking maturities from each of two growing districts were represented (or 8 lots in all). At the start of the storage experiment 4 open chipboard trays (containing 5 lemons each) were prepared from each of the eight lots referred to above and overwrapped with moisture-proof cellophane, 350 MSAT. Two of the packages were perforated with 2 one-quarter inch holes, and one perforated and one non-perforated package placed at each of two storage temperatures, namely 38° F. and 55° F. Inspections were made on the 32 packages at the end of a 4-week storage period. A similar set of 32 packages was prepared from lemons packed in standard boxes that had been held in storage for four weeks at either 38° F. or 55° F. (the lemons prepackaged from them being returned to the same temperatures for another four weeks). Likewise a third set of 32 packages was prepared from standard crates that had been in storage eight weeks at either 38° or 55° F. - the prepackaged lemons being returned to their respective temperatures four additional weeks.

The results obtained, although not here presented in tabular form, were much the same as with test 4. There was practically no depletion of oxygen or build-up of carbon dioxide in the perforated packages. Approximately 25 percent of the non-perforated packages showed a carbon dioxide build-up of five percent or greater (up to ten percent) and a similar percentage showed a depletion of oxygen within the enclosed atmosphere to fifteen percent or less (with a minimum concentration of twelve percent). No abnormal odors or flavors were noted throughout the test. When the prepackaged lemons were examined at the conclusion of the several 4-week storage periods membranous stain was found alike in both perforated and non-perforated packages. No relationship was found between incidence of membranous stain and carbon dioxide or oxygen content of the enclosed atmosphere in the non-perforated packages. Practically no decay occurred during the test.

Discussion and Conclusions

The tests here reported show that a number of different transparent films can successfully be used for the prepackaging of lemons. The chief difference between the several films tested lay in the relative rate of weight loss and consequent shriveling of the prepackaged fruit. This, in turn, resulted in differenses in length of shelf life or the period during which the prepackaged lemons were considered to remain in a salable condition. Weight loss, shriveling of fruit and consequent variation in shelf life were also dependent upon the storage temperature at which the lemons were held after prepackaging.

The first two tests indicated that by prepackaging lemons with either perforated or non-perforated moisture-proof cellophane they could be held in good fresh salable condition for one or possibly two weeks at 70° F. and for three or possibly four weeks at 50°. Semi-moisture-proof cellophane, cellulose acetate, and kraft paper window bags permitted such rapid weight loss at 70° that lemons so prepackaged behaved very similarly to unwrapped lemons and should probably have been packaged only for immediate display and sale. However, when held at 50°

following prepackaging, lemons in cellulose acetate and kraft paper window bags had a shelf life of one week and those in semi-moisture-proof cellophane bags a shelf life of one or possibly two weeks.

In the third test it was found that lemons overwrapped with perforated or non-perforated Pliofilm and perforated or non-perforated moisture-proof cellophane remained in good salable condition for two weeks at 70° F. Lemons overwrapped with either non-perforated semi-moisture-proof cellophane or non-perforated cellulose acetate as well as unwrapped fruit had a shelf life of only one week at 70° F. because of moisture loss and shriveling of the fruit. On the basis of such factors as weight loss and freshness of fruit, shelf life of unwrapped lemons held at either 42° F. or 50° was two weeks, while lemons overwrapped with cellulose acetate held up well for two to three weeks, and those overwrapped with the other films had a shelf life of four weeks.

The final two tests showed that, to all appearance, lemons were little affected by four weeks enclosure in non-perforated moisture-proof cellophane even when a pronounced build-up of carbon dioxide and depletion of oxygen occurred. There was likewise no effect on development of membranous stain by enclosure in non-perforated moisture-proof cellophane. It should be pointed out, however, that equally good results were secured with perforated as with non-perforated moisture-proof cellophane; where Pliofilm was used results likewise were the same with the perforated as with the non-perforated film.

From a commercial viewpoint it would appear that a wide variety of films can be used in prepackaging lemons - particularly if the fruit is packaged for prompt retail distribution. If it is desired to prepackage some time before the lemons are to be placed on sale, the chief factors that need to be considered are decay and shriveling of the fruit.